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Method for Measuring Stress and its Equipment

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Specifications

**Name of Invention**

**Method for Measuring Stress and its Equipment**

**Scope of Patent Claim**

1. The device applies repeated loads to a test object using an infrared ray which strikes said test object from a microscopic point, which detects variations in temperature synchronous with the loads described above applied to the test object. It has features such as changing the position of the microscopic point, which detects changes in temperature.
2. The change in position mentioned above is executed one-dimensionally as in Paragraph 1.
3. The change in position mentioned above is executed two-dimensionally as in Paragraph 1.
4. The change in position mentioned above is executed in a procedural fashion as in Paragraph 1 or in Paragraph 3.
5. The change in position mentioned above is executed consecutively as in Paragraph 1 or in Paragraph 3.
6. The earlier-described loads are pressure and/or stress loads as in Paragraph 1.

7. The earlier-described loads are loads in which fluctuating weight was weighed as fixed loads as in Paragraph 1.

8. The device for measuring stress is equipped with a detector for detecting infrared rays emitted from a test object which has loads repeatedly applied to it; a measure for scanning images from the detection means at long cycling periods for the earlier described loads using samples; circuits for selecting alternating current signals in the detected signals obtained from the aforementioned detector with scanning capabilities; a rectifier circuit, supplied with the aforementioned signals; and a display device, which has its power supplied by output from said rectifier circuit.

9. The above-described rectifier circuit is a circuit synchronous with the load cycles mentioned previously in Paragraph 8.

**Detailed explanation of the Invention**

This invention is a device related to the equipment and the method for measuring stress, which can measure stress for a short period of time without the need for contact.

It is used to produce mechanical accessories, and it is essential to note

any stress (caused by loads) not concentrated in a specific position.

In the area of aviation where particularly durability is focused on, stress is applied to the actual machines or to the exterior of model surfaces equipped with several elliptical gauges, which resemble the actual machinery, then each gauge is integrated and the stress value for each part and the division of stress are measured.

Until recently, however, this kind of method required a long amount of time for installation, and one flaw was that it was difficult to use on a small test object, given the size of the gauges.

The present device has considered these issues, as its purpose is to offer equipment and novel means of being able to measure stress and possibly the division of stress quickly without contact by obtaining the variation in temperature from the cycle loads applied. This invention is explained in detail in the plans below.

At the point the surface temperature on the test object was measured once the cycled pressure loads and the tension loads were applied to the test object, we discovered that the surface temperature did not increase only in the area where the inventor(s) focused on, and the period where the surrounding temperature synchronous with the rising loads applied and the period where it declines are repeated in an alternating fashion. When the load of the sine wave shown in Diagram 1 is applied to the sample, the result is that the period where the surrounding temperature becomes low and the period where it becomes high shown as a sinusoidal waveform synchronized with a load applied, which the surface temperature at the area where the stress on the sample is concentrated indicates in the same diagram (b), are repeated in an alternating fashion.

The heat generated is shown where the stress is concentrated during the period where the before-mentioned effect is

increased by compression; and for the period where tension is increased, the heat absorption is shown. Because this generated heat and this absorbed heat repeat at relatively short periods, the above-mentioned area where the stress is concentrated at changes at a point where the insulation is weaker from the distribution of heat to its surroundings or by an influx of heat coming from the environment. It has been verified that only rising temperatures from rectangular waves synchronous with it exist, as shown in the first diagram, for example, or in the same diagram (d) where compression only is added by rectangular waves, and if only tension is applied, such as in (a) of the same diagram, only declining temperatures exist as seen in (f). It was established that the results from changing several states then repeating experiments and cycle tests and the relationship between the change in temperature and the change in stress (for an accurate measure of the change in position caused by stress) share a proportional relationship.

The relationship between the change in temperature of the load where (a) and (b) in the second diagram found in the experiments and the change in the surrounding temperature is shown. Cycle loads are applied to the measuring device as a result of this relationship, and if temperature variations at specific parts of the surface are detected, it is possible to know that there is stress in those parts and if the specific areas are horizontally scanned in a gradual progression, it is possible to know the distribution of stress, which was repaired in the scan lines. Also, if the position of the scan lines moves slowly in a vertical direction, it is possible to measure the two-dimensional division of stress within the scanned region.

Diagram 3 shows an example composition of how to use this invention based on this concept. In reference to

the same diagram, 1 is the vibration device. vibration mechanism 1 provides preservation mechanisms 5 and 6 in order for test object 4 to be locked in between pistons 2 and 3, which are powered hydrodynamically.

Reference numeral 7 is a detector used for detecting infrared rays coming from test object 4. The image in detection means 7 is projected on the test object by focusing lens 8 (a mirror) and is raster scanned in test object 4 by horizontal scanning mirror 9, which is arranged by an optical path, and vertical scanning mirror 10. In other words, the infrared rays emitted are detected using the strength, which corresponds, to the temperature coming from the microscopic point on the test object where the detected image is projected in detection means 7. The detected signal acquired which was accompanied by raster scanning is sent to the lineariser 12 through amplifier 11, and the linear connection with the temperature is converted to a temperature signal. 13 is the filter used for producing only an alternating current signal (the amount of fluctuation) from the acquired temperature signal and then that signal is sent to the synchronous rectifier circuit 14. In the synchronous rectifier circuit 14, it is supplied by signal synchronous with the loads applied from vibration mechanism 1.

The output synchronous rectifier circuit 14 is sent to recorder 16 or memory 17 through exchange circuit 15.

18 is an A-D conversion means for converting the output to a digital signal. 19 is a memory control circuit which regulates data storage addresses based on a signal synchronous with the abovementioned horizontal scanning mirror 9 and the scanning from driving source 20 and 21 in vertical scanning mirror 10. 22 is a cathode-ray tube (CRT) display device, which displays an image sequentially reading data stored

in memory 17. In the above composition, such a situation where the division of the one-dimensional stress of one raster is measured first is explained. In such a case, the vertical scanning from the vertical scanning mirror 10 is stopped at an appropriate location, and only scanning from horizontal scanning mirror 9 is executed for several hundred seconds at a location connected to the time as shown in the Diagram 4 (a). This vibration mechanism 1 applies repeating tension loads and pressure loads from the rectangular waveforms in sample 4 at a frequency between 1Hz and multiple Hz, as shown in Diagram 4 (a).

The 4th diagram (c) shows the temperature signal waves obtained from lineariser 12 and understands the change synchronous with the load applied in vibration mechanism 1, the core for the signal value  $V_o$ , which corresponds with the temperature in the surroundings. The range of the variation corresponding to the size of the load in that location was expressed previously. Strictly speaking, the detection point, in the time when pressure loads are applied then tension loads are applied, shifts, but it is not possible to find the range in temperature variation at that same point, so because in actuality horizontal scanning is done slowly when compared to repeated loads applied from the vibration mechanism, it is acceptable to ignore the shifting detection point. (Conversely, the horizontal scanning speed is configured in order to accommodate for this condition.) The temperature signal shown in Diagram 4 (c) removes the direct current amount  $V_o$  through Filter 13 and only the alternating current signal is sent to the rectifier circuit 14. Because rectifier circuit 14 detects the alternating current signal at the same time based on the signal synchronous with the loads applied as shown in

Diagram 4 (d), the output of rectifier circuit 14 is obtained by the stress signal corresponding to the range in variation synchronous with the cycle loads for the temperature signal as shown in Diagram 4 (e). Also, because it is rectifying at simultaneously, in the event the change in temperature is in-phase with the vibration mechanism, the sign for the stress signal will be correct, and because conversely the signal will be incorrect, it is possible to have either the pressure load be at the location it is in when a bending load is applied (e.g. to a sample) and at that location in the event there is a tension load and have some share of the loads or separate them if the signal is incorrect. The stress is sent to record 16 through exchange circuit 15 and is recorded as a one-dimensional stress waveform. Also, there is an example above on how to do a horizontal scan consecutively, but it should be done in steps.

Next, when division of two-dimensional stress is measured, consecutive or step-by-step vertical scanning from scanning mirror 10 will be added, and exchange switch 15 will be brought down to the measurement from the memory. In the first of each horizontal scanning, scanning mirror 10 shifts the scanning location gradually in a vertical direction, and the stress signal, which is shown in Diagram 4 (e), obtained by each horizontal scanning accompanied by the first, is converted from A-D transmitting means 18 to a digital signal, and then is stored in memory 17. Once the first vertical scan is completed, the stress signal acquired from, for example, the 120 horizontal scans, is stored in memory 17, and the stored stress signal is read sequentially as brightness signals to the raster-scanned CRT display device 22 and for it to be dispatched, the sample image, which gives brightness based on the amount of stress, will be displayed in the display screen. Then, the operator

can easily distinguish the brightness from the concentrated amounts of high stress based on this image. The image display should display the image with varying degrees of brightness, and other display methods have a set brightness signal on, for example, the raster-scanned CRT, and the so-called "varying method of display," which has the stress signal weighed with signals for vertical and other directions, may be used.

Next, in the above-mentioned examples for practical use, stress signals are converted to digital signals and then stored into the memory, but there is nothing said about any photographic analog imaging memory used which does not have this limitation, e.g. a scanning converter.

Also, there should be sinusoidal waveforms, which are not limited to load waveforms and rectangular waveforms. The direction of the loads should be applied to the pressure path or the tension path only as illustrated in Diagram 1 (c) or (d), and fluctuating amounts should be weighed as fixed loads. It is not said that when measuring the applied loads already cycled, such as currently running machinery, vibration mechanisms are unnecessary.

Furthermore, in the above-mentioned examples for practical use, because synchronous rectifier circuits are used as rectifier circuit, the improvement of S/N proportion compared to simple rectifier circuits is [illegible], but if it is not needed, it is not said that simple rectifier circuits should be used.

It is possible to measure the distribution of stress in an extremely short period of time compared to devices made up to this point and without contact if using a device similar to this invention. In addition, there are many devices up to this point, which had used gauges for measurements do not compare to this device nor be able to measure the distribution of stress.

**Simple explanation of the diagrams**

Diagram 1 explains the fundamental principle of this invention.  
Diagram 2 indicates the load and temperature variation and temperature of the surroundings.  
Diagram 3 shows an example composition for this invention.  
Diagram 4 explains its behaviour.

1: vibration mechanism  
4: test object  
7: infrared ray detection means  
9,10: scanning mirrors  
12: lineariser (?)  
13: Filter  
14: synchronous rectification circuit  
16: recorder  
17: memory  
19: memory control circuit  
22: CRT display device

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**Diagram 1**

- (a) Pressure load, Tension load
- (b) Temp. of surroundings
- (c) Pressure
- (d) Temp. of surroundings
- (e) Tension
- (f) Temp. of surroundings

**Diagram 2**

- (a) (on Y-axis) change in temperature, (left on X-axis) tension, (right on X-axis) load
- (b) (Y-axis) change in temperature, (X-axis) temp. of surroundings

**Diagram 3****Diagram 4**

- (a) Scanning location
- (b) (top) Pressure, (bottom) tension